Make Sure Requirements Are Developed Correctly

The Problem:

As a planetary probe neared its objective, a potentially crippling flaw was discovered—the designers had neglected to take the Doppler Effect into account.

The Cause:

After a seven-year journey toward one of the Saturn's moons, the probe will enter the moon's atmosphere, collecting data during descent for relay to the Earth via an accompanying orbiter.

As the probe speeds away from the orbiter, the data signal frequency will drop slightly, due to the Doppler shift. According to the Inquiry Board Report, this unavoidable frequency drop was overlooked from initial project requirement determination all the way through design specification of the orbiter's receiver. Extensive internal and external reviews failed to discover this oversight, in part due to a proprietary issue. Later, the design flaw escaped the system-level test because an incorrect frequency was used.

Two and half years after launch, a check-out of the probe indicated that the signal frequency was outside the receiver's bandwidth. Had the problem been unveiled on the ground, it could have been fixed with a simple software patch. Unfortunately, the software is not accessible in flight.
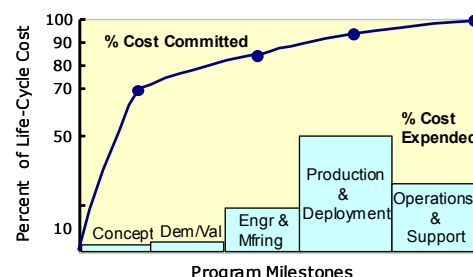
To minimize the Doppler shift, the flight trajectory had to be changed, at considerable expense in fuel, so that the orbiter will be farther away from the probe as it descends.

Most of the project's cost and performance are established by front-end decisions, but mistakes made there are difficult to catch. More resources, including the most experienced personnel, should be made available to ensure the early decisions are made properly.

Designers should thoroughly review the history of similar projects. If the probe designers had analyzed the requirements of other deep space projects, both the importance of the Doppler shift and the correct way to perform end-to-end test would have become obvious.

Lessons Learned:

- Formalize requirement development process and capture lessons.

- Provide adequate design margins and operational flexibility, such as the ability to use software patches.

- Make sure that the hardware or software a contractor wants to reuse from another program is indeed applicable and has a satisfactory flight history. Do not be deterred by the excuse that details are not available because the previous program was proprietary or classified—there are always ways to get around that hurdle.

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